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Donald
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ENCYCLOPEDIA OF

ARCHITECTURAL AND ENGINEERING **FEATS**



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Encyclopedia of Architectural and Engineering Feats

Encyclopedia of Architectural and Engineering Feats

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Preface

The engineer, inspired by the law of economy and governed by mathematical calculation, puts us in accord with universal law. He achieves harmony. The architect, by his arrangement, of forms, realizes an order which is pure creation of his spirit. By

the relationships which he creates he awakes profound echoes in us, he gives us the measure of an order which we feel to be in accordance with that of our world. Le Corbusier, Vers une Architecture (1923)

This book offers an overview of the architectural and engineering works that represent major steps, as well as significant innovations, in the creation of the built environment. Its scope is wide in both time and space, presenting achievements from prehistory until the present, including work in progress, in all the inhabited continents—one entry even describes a building in outer space.

Not all these feats were performed by trained architects or engineers, or by others acting in any professional capacity. We have concluded that some of the more awesome accomplishments and exciting responses to what seemed to be insurmountable challenges have been the work of communities that many people might regard as underdeveloped. That leads us to the observation that the greatest achievements have depended, not on the sophistication of a culture's technology, but on the social imperatives that stimulated people to push the available technology to its limits. In the ancient and preliterate world, corporate will, brilliant social organization, and shared commitment to a spiritual ideal

were as powerful influences upon the creation of the great works of humankind as any of the inventions of the Industrial Age.

Therefore, the reader will find in these pages many references to feats that were in effect social products. It is generally true of the ancient and medieval worlds that architects and engineers stood deep in the shadow of their patrons, although a few individuals like Hippodamos, Iktinus, and Mnesikles are identifiable. But the patrons are usually better known: for example, Perikles, Hadrian, and Charlemagne. The closer we come to the present, the more often particular personalities stand out; architects and engineers are

identifiable, and some are even famous. The watershed seems to have been the fifteenth-century Italian movement known as the Renaissance, defined 400 years later by the Swiss historian Jacob Burckhardt as “an affirmation of the individual, who emerged from the anonymous crowd of the Middle Ages.”

Had we restricted ourselves to the *major* steps forward—new structural systems and new building materials—this would be a slim volume indeed. They have been few and far between. Throughout

its entire time on Earth, humanity has discovered just three essential ways of building: post-and-beam, or trabeated, construction; the arch and its extensions, the vault and the dome, known as arcuated construction; and the use of stretched filaments and membranes to produce a tensile structure. The ways in which each has been applied at different times and in different places have depended not only upon what materials were available but also upon beliefs about how long a building should last. Until about 150 years ago the most

durable material was stone, whether naturally occurring or replaced by synthetic variations—that is, brick or concrete. Each develops great compressive strength (resistance to crushing) but readily fails in tension (when it is stretched). For millennia, that limiting physical property confined builders to the trabeated or arcuated structural systems. Durable tensile materials (steel and reinforced concrete) were not developed until the late nineteenth century A.D.; synthetic membranes did not appear until a whole century later. Before that, tensile systems were used only in structures like Bedouin tents, which were nonetheless remarkable feats for their economy of

means, functionality, and environmental sustainability.

Naturally, there were developments, often born of necessity, within the narrow range of appropriate structural systems. The prehistoric peoples of the stone-poor Egyptian, Mesopotamian, and Pakistani river valleys invented the brick, later making it more durable by baking it in kilns. In the second millennium B.C. the warlike Mycenaeans, having invented the “relieving triangle” to reduce loads over openings, extended and refined it to form corbeled vaults and domes. Over a thousand years later, the Romans developed the arch—known to, but rarely used by, the ancient Egyptians—

and exploited its space-forming potential in all manner of variations built in concrete. Around A.D. 500 Byzantine engineers found a way to build domes above square compartments by inventing the pendentive. After that, at least in the West, no advances were made for another five centuries.

Then, in a thrilling burst of creative activity, the itinerant master masons of France, England, and Germany produced the great Gothic churches. Ironically, those revolutionary structures were made possible by the adoption of an Islamic invention, the pointed arch; together with rib-and-panel vaulting and the flying buttress; that simple device formed the structural essence of a new

framed architecture, giving a hint of things to come. From about A.D. 1500 building technology suffered another 300-year hiatus. The Renaissance—whose architecture Victor Hugo called “the sunset that all of Europe mistook for dawn”—saw the mason-architect replaced, first with the artist-courtier-architect and finally with the abstruse academician. The structural adventure all but ceased.

Late in the 1700s, metal building frames were developed, first in iron, a material that also worked best in compression. A century later the technological revolution produced steel, and subsequently reinforced, prestressed, and shell concrete. Since

then, structural innovation has accelerated, culminating in the creation of buildings beyond the earth.

The works and ideas in this book have been chosen for any of several reasons. Some represent those erratic major leaps in the use of materials or technology but many exemplify the creative refinement of existing systems. Others, like Frank Lloyd Wright's Frederick C. Robie house in Chicago, are socially significant. Still others are inspired responses to economic needs: for example, the architecture associated with the railroads or the building of the Panama Canal. Some, like the Deltaworks in the Netherlands or China's Three Gorges Dam, are works

that have been undertaken on an almost unimaginably ambitious scale. A few others are not structures at all, but individuals, ideas, or institutions that have generated new directions in engineering or architectural thought, leaving their mark on the built environment. No entry is included on the basis of a single factor. Although inevitably there are certain emphases, each feat is considered within a cultural, social, artistic, and technological context. Wherever possible, we have included information about the condition of the structures at the time of writing: a fact borne out poignantly in the final entry—the World Trade Center Towers in New York. This book was due to go

to press when the twin skyscrapers were destroyed on 11 September 2001 by a terrorist attack that claimed a multitude of innocent lives. The apparent ease and swiftness of their destruction is a sobering reminder,

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not only of the fragility of life but also of the structures that we build.

We are grateful to the University of South Australia for practical support and encouragement during the compilation of this book, and especially to the library staff at the City West Campus. Thanks are also due to Caryl Bosman, who found and photocopied reference material for us. We have appreciated and enjoyed the opportunity to collaborate with ABC-CLIO editorial staff in the preparation of this encyclopedia and thank them warmly for their

encouragement and gracious assistance.

Of course there will be objections to our choice of subjects, especially over what has been omitted. Our only answer is that we could not include everything. We have tried to avoid embracing structures merely because they are the biggest of their kind, because records for height, span, or capacity are regularly broken. Rather, we have sought to identify those achievements that demonstrate discovery, creativity, and innovation, as well as those that manifest humanity's propensity to "just do it," especially against the odds. As Arnold Toynbee once pointed out, societies and individuals perform at their best, not

when life is easy but when they are faced with a challenge. As the reader will discover, at those times the result has been a remarkable and exciting architectural or engineering feat.

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